MEMORANDUM REPORT ARBRL-MR-03303

COMPUTER AIDED DESIGN OF POLYHEDRON SOLIDS TO MODEL AIR IN COM-GEOM DESCRIPTIONS

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Certain target vulnerability analysis performed at BRL require (COM-GEOM) simulations which include internal air in the description. This report describes an interactive program which aids the user in describing such internal air. A simple example is included in this report in which the procedure is described in a step-by-step fashion.

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I. INTRODUCTION

Vulnerability/lethality analyses performed at the Ballistic Research Laboratory (BRL) generally require a computer description of the target under investigation. The target simulation is most often accomplished through a method known as combinatorial geometry (COM-GEOM). The resulting target descriptions are commonly referred to as COM-GEOM[1,2] descriptions. The COM-GEOM technique for target descriptions employs a variety of basic geometric solids in order to model all of the components of the target. The BRL tank vulnerability program[3] is routinely used to estimate the vulnerability of many armored targets. In particular, this program requires the COM-GEOM target descriptions to include internal air modeled in the description.

This report describes the interactive program CADAIR which aids the user in describing internal air for COM-GEOM descriptions. The program is useful during the creation phase of a COM-GEOM description or in modifying an earlier COM-GEOM description which lacked internal air. In addition, various other capabilities of the CADAIR program are discussed.

II. BACKGROUND

The BRL tank vulnerability computer program (VAMP) is based on the "compartment model" of vehicle vulnerability. In this lethality model, damage correlations for entire compartments are considered in order to arrive at final kill probabilities for the target. Usually the vehicle is divided into two compartments: the engine compartment and the crew compartment. It has been found convenient to identify "compartments" by describing the compartment air in the COM-GEOM description. The target description air is merely coded in order to distinguish the crew compartment (02) from the engine compartment (05). Special other compartments may similarly be identified by this technique.

---

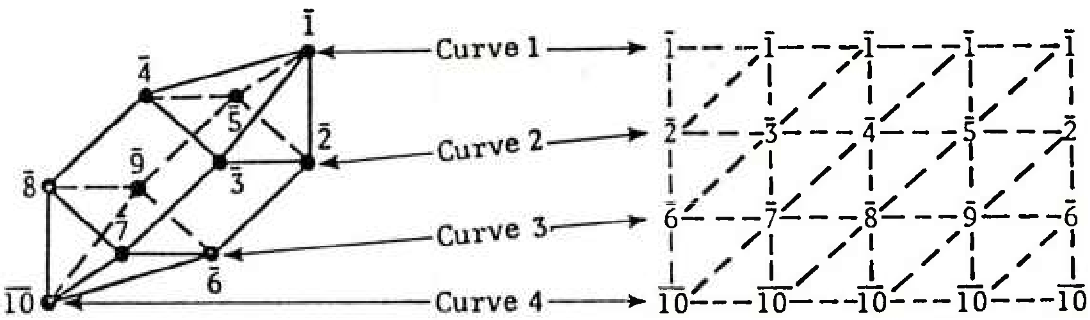
[1] *L. Bain and M. Reisinger, "The GIFT Code User Manual, Volume I, Introduction and Input Requirements," BRL Report No. 1802, July 1975 (Unclassified). (AD B006037L).*

[2] *G. Kuehl, L. Bain and M. Reisinger, "The GIFT Code User Manual, Volume II, The Output Options," BRL Report ARBRL-TR-02189, September 1979 (Unclassified) (AD A078364).*

[3] *C. Nail and T. Bearden, "Vulnerability Analysis Methodology Program (VAMP) A Combined Compartment-Kill Vulnerability Program," Computer Sciences Corporation, October 1979 (Unclassified).*

III. TARGET DESCRIPTION

A brief summary of the COM-GEOM technique is presented in Appendix A. The descriptions utilize a variety of basic geometric solids for describing the actual target. The solid types currently available for building COM-GEOM descriptions are listed in Table A-1. These solids, with the exception of the ARS, are fundamentally simple geometric shapes. The ARS (triangular surfaced polyhedral solid) may be used to model extremely complex shapes. Figure 1 illustrates the essential characteristics of the ARS solid.



SPECIFY: **The X, Y, Z coordinate values of the vertices of the concave or convex polyhedron. Either 1) order and record the vertices by the number of curves (M) and number of points per curve (N) system or 2) order and record the vertices by the scheme associated with the SHOT GENERATOR Code and specify the number of recorded points (ND).**

Figure 1. Basic ARS Solid

Both the number of curves and number of points per curve may vary considerably from that shown in Figure 1. An example of the possible complexity of the ARS solid is shown in Figure 2 which depicts an entire surface of a tank turret. The versatility of the ARS solid makes it ideally suited for describing interior air in target descriptions.

In order to avoid errors, the user must exercise caution when modeling air in the COM-GEOM description. Figure 3 shows a cross section of a tank turret which has two types of errors that may occur if the internal air is modeled incorrectly. If the internal air (bounded by solid line) does not "fill up" the interior compartment volume or if it "spills over" the exterior surface of the compartment, then errors will occur during further computer processing. An acceptable modeling technique for internal air is illustrated in Figure 4. Note in this figure that the boundary of the internal air is defined within the shell wall which identifies the compartmentalized volume.

In view of these constraints and the previously noted versatility of the ARS solid, it therefore is apparent that this solid type is well suited

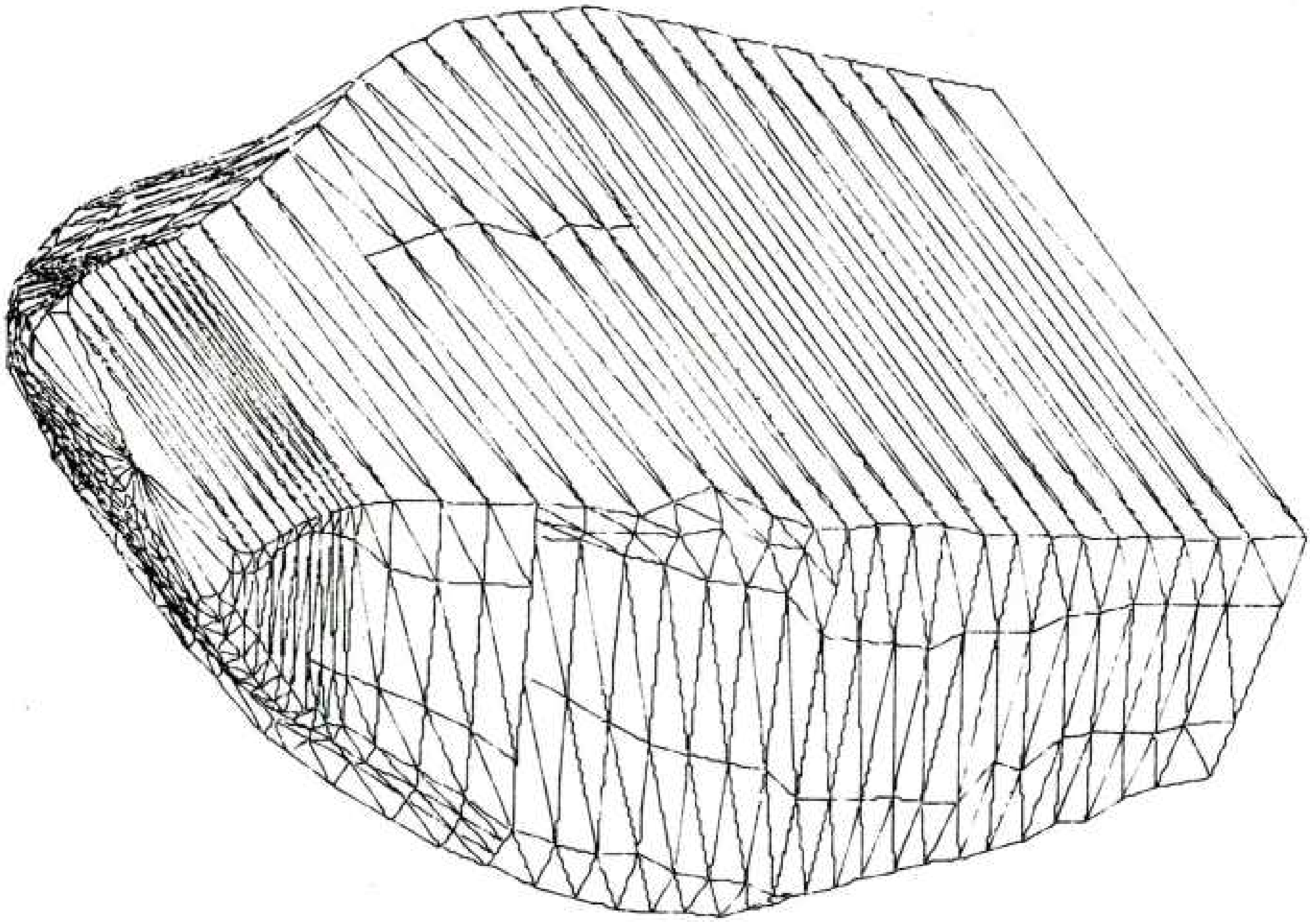


Figure 2. Example of Large ARS Solid

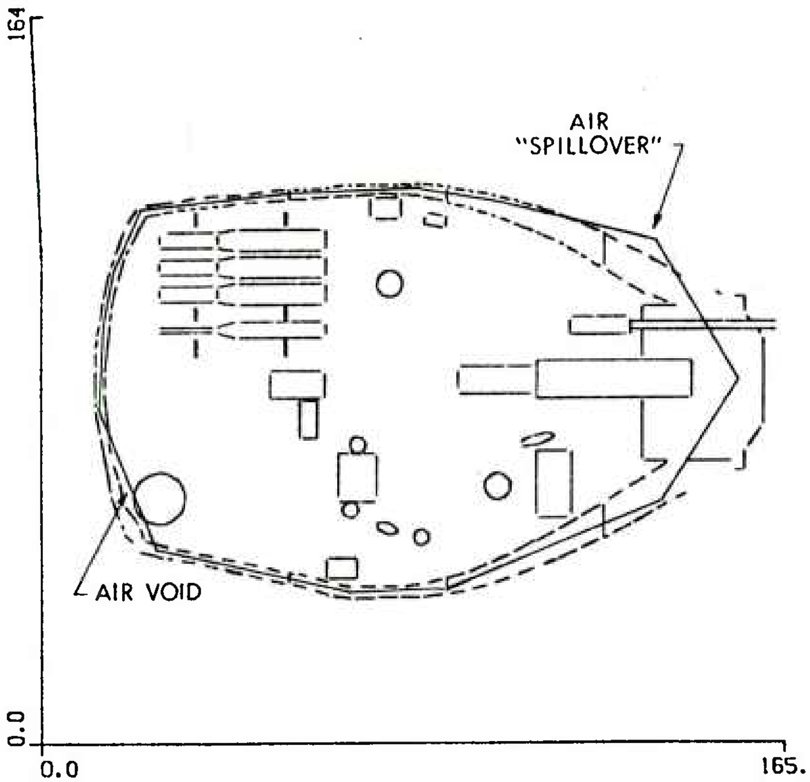


Figure 3. Example of Air Modeling Errors in COM-GEOM Description

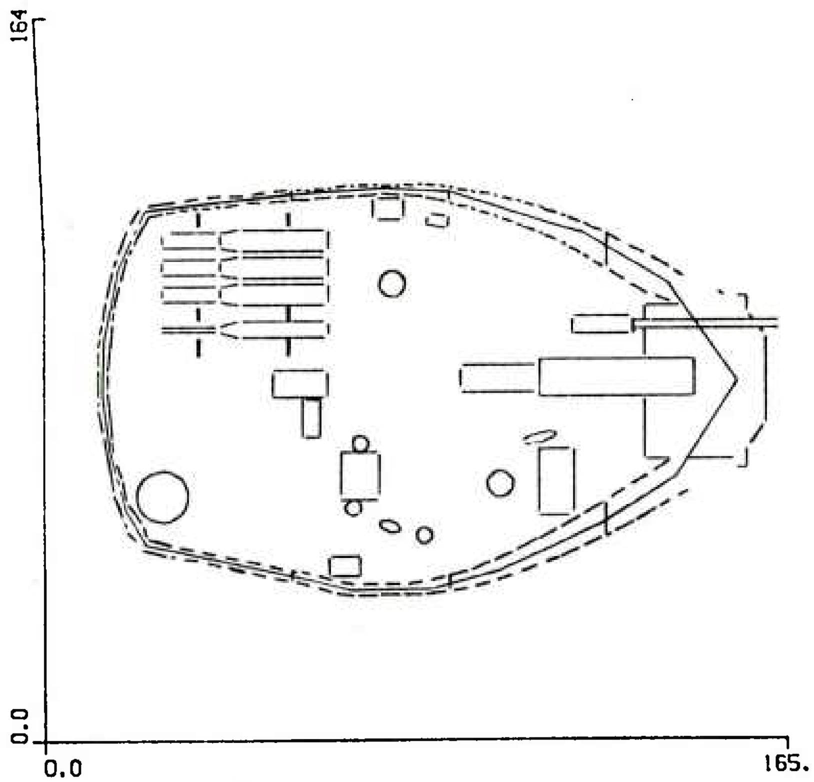


Figure 4. Example of Acceptable Modeling of Air in a COM-GEOM Description

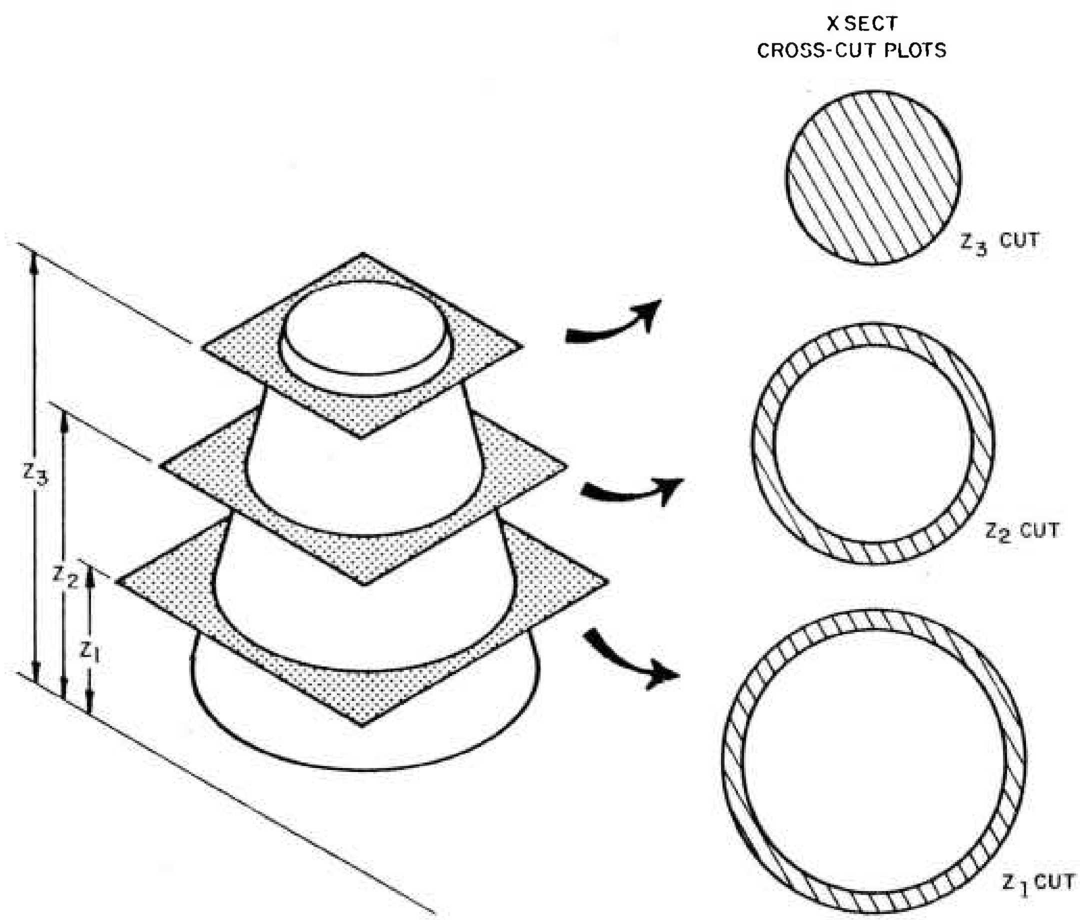


Figure 5. Inverted Tumbler Cross-Cuts

for modeling internal air. The purpose of the CADAIR program is to aid the user in constructing an ARS solid which will conform to the aforementioned requirements.

IV. CADAIR PROGRAM OVERVIEW

CADAIR is an interactive graphics program for use with a TEKTRONIX[R] terminal operating within the NOS (version 1.4) environment. The Network Operating System (NOS) controls the operation of CDC CYBER 170 series, CDC CYBER 70, Models 71, 72, 73, and 74, and CDC 6000 series computer systems. CADAIR is a FORTRAN program which requires the library software package DISSPLA[R] which is a proprietary product of ISSCO[4]. The program CADAIR listed in Appendix B is currently used at BRL in conjunction with a TEKTRONIX[R] model 4010 terminal operating at 9600 baud.

CADAIR requires input which is generated from the GIFT[2] code under option XSECT. This option produces plot files which define cross-sectional views of the COM-GEOM description. Reference 2 is recommended for the reader unfamiliar with the XSECT option of the GIFT code. An example of this type of plot for the case of a simple inverted tumbler is illustrated in Figure 5.

The use of the CADAIR program for describing air within the inverted tumbler (Figure 5) will serve as an example in the following section. The user is free to select any number and location of cross-cuts when using the XSECT option of the GIFT code. The judicial selection of cutting planes which reflect "moderate" changes between succeeding cross-cut shapes is recommended. In the normal use of the XSECT option, there is no information relating to the position of the cutting plane (Z value) available in the plot file output. This third coordinate information (Z values) is clearly vital for describing an ARS solid in three dimensional space. However, a simple method for accomplishing this is readily available. The regular XSECT plot title may be replaced with the number of cutting planes and their respective locations (Z values). Figure 6 shows the prescribed format to be used for replacing the TITLE card for the XSECT option of the GIFT code.

I5 NUM	F5.0 Z1	F5.0 Z2	F5.0 Z3		....	F5.0 Zn

NUM- Total number of cross-cuts in plot file (not to exceed 20)

Zi- Cutting plane position (Z-value) for i th cross cut in the COM-GEOM coordinate system

Figure 6. Title Replacement Format for XSECT Input

[4]*Integrated Software Systems Corporation, ISSCO[R], San Diego, CA 92121*

The CADAIR graphics program displays each of the cross-sectional plots on the graphics screen and prompts the user to select points for each ARS curve. The user inputs the (X, Y) values for these points by manipulating the position of the cross hairs that appear on the graphics screen. Advantage from visual feedback thereby aids the user in fitting the ARS curve entirely within the shell wall boundary around the internal compartment. The user may save the ARS data file (punch) thus created at the conclusion of the point selection procedure from each cross-cut plot. This file is appropriately formatted for use in a COM-GEOM description.

V. CADAIR PROGRAM USER GUIDE

The CADAIR program currently in use at BRL is accessed by entering the commands that are listed in Figure 7 on a TEKTRONIX[R] 4010.

```
GET,TAPE12=PLTFILE/UN=SHIELLS
ATTACH,DISSPLA/UN=DISSPLA
LIBRARY,DISSPLA
GET,GOX/UN=SHIELLS
GOX
```

Figure 7. MFB Commands to Access CADAIR Program at BRL

In Figure 7, PLTFILE is the plot file output from the XSECT option of the GIFT code that was discussed in the previous section. File DISSPLA is the proprietary graphics software product of ISSCO. In Figure 7, GOX is the binary file which contains the compiled CADAIR program.

When the last command in Figure 7 is entered on the terminal keyboard, the screen is cleared and the MENU is displayed.

Figure 8 shows a copy of the MENU which appears on the graphics terminal. The terminal cross hairs also become visible at this time. A keyboard response from the terminal user is required whenever the cross hairs become visible.

The required response generally requires the user to change the location of the cross hairs and then push any punctuation key on the keyboard instead of the carriage return (CR). The position of the cross hairs is changed by two dials (horizontal and vertical) available to the user near the terminal keyboard.

```
REWIND
BACKTRACK
DISPLAY
BUILD ARS
ZOOM
EXIT
```

Figure 8. CADAIR MENU

The MENU lists several different procedures available to the user. The user may optionally select any procedure by merely positioning the horizontal cross hair over the name of the procedure and then pressing any punctuation key. When the procedure is completed the MENU will reappear on the screen.

The explanation of each procedure (MENU item), supplemented with illustrations, follows:

REWIND	This MENU entry permits the terminal user to rewind the entire plot file. This is a minor procedure that helps the user when previewing the various cross-cuts plots on PLOTFILE.
BACKTRACK	This MENU entry permits the user to back up the plot file (PLOTFILE) in order to preview the previous cross-sectional plot.
DISPLAY	This procedure displays the current cross-section plot in PLOTFILE on the graphics terminal. Figure 9 illustrates a typical example of a cross-sectional view of a tank turret. Successive use of this procedure allows the user to preview each cross-sectional plot in the plot file (PLOTFILE). This procedure may also be applied to plot files generated by the PICTUR option of the GIFT code if one condition is satisfied. The title card (Figure 6) used for the PICTUR run should be blank. Effectively the plot file output from PICTUR could be edited to accomplish the same thing. Figure 10 illustrates a typical perspective view of a tank which was produced by the PICTUR option of the GIFT code.

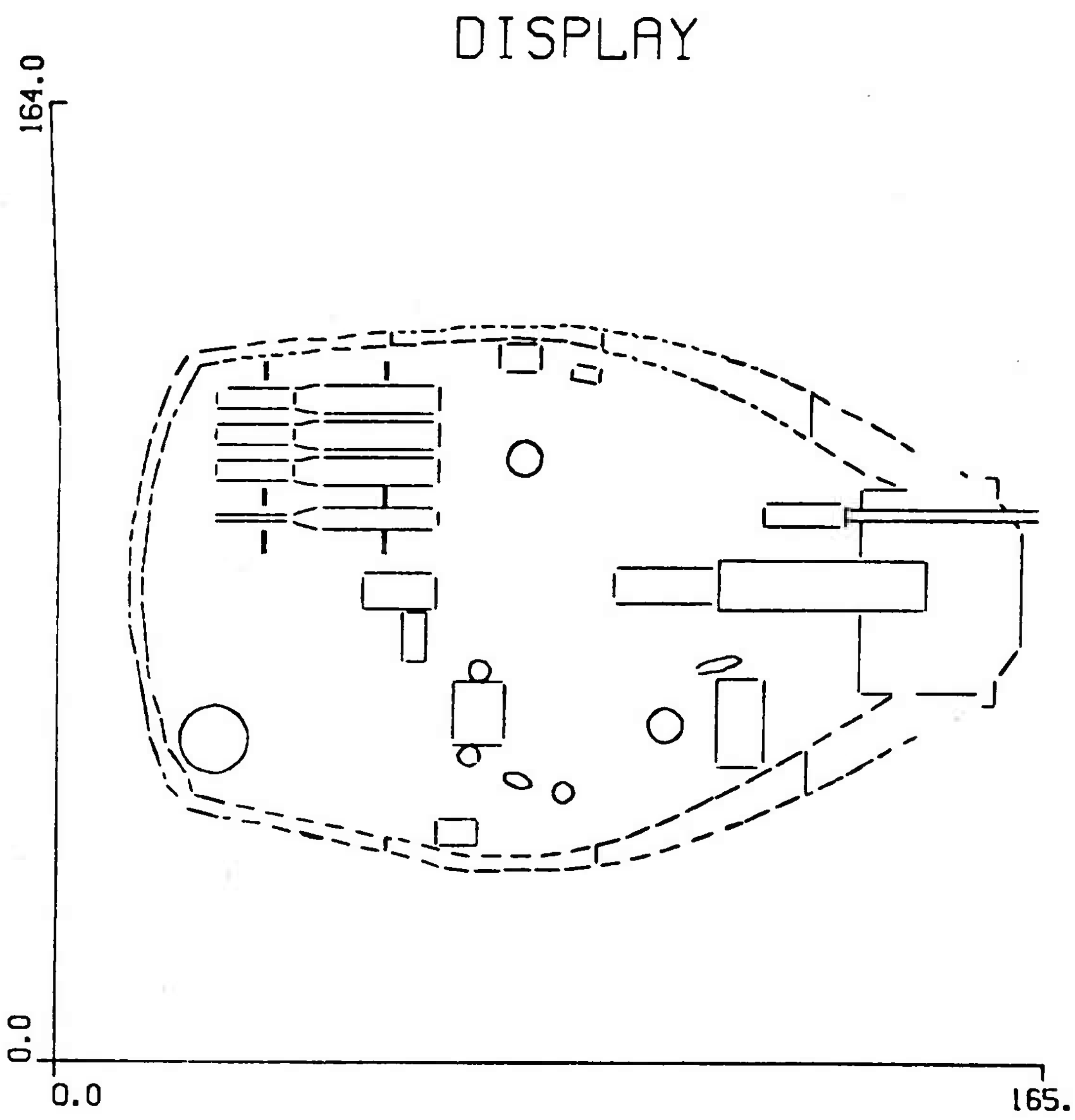


Figure 9. DISPLAY Cross-Section Example

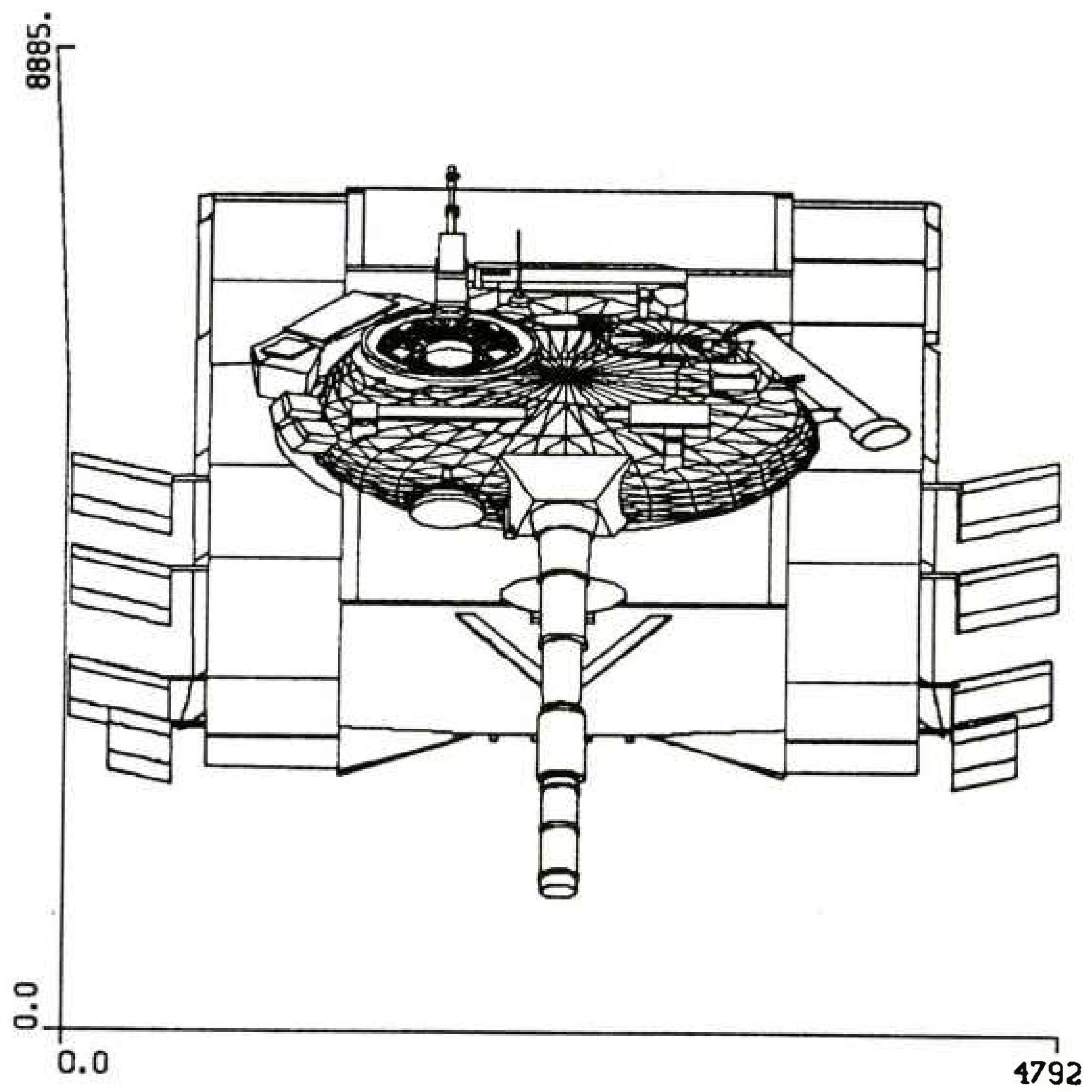


Figure 10. DISPLAY Perspective View Example

BUILD ARS

This procedure encompasses the overall purpose of the CADAIR program. When this procedure is initiated, the plotfile is automatically rewound. Figure 11 shows the first cross section (with prompts) which is displayed for the example of the inverted tumbler. A requirement for the ARS solid is that the first and last curves degenerate around a single point. Therefore, the user is prompted by the message "SELECT FIRST ARS POINT/CURVE." The user is expected to position the terminal cross hairs so that they intersect within the shell wall boundary of the displayed cross section. The user then presses any punctuation key to send the cross hair X and Y positional information to the host computer. The program resumes by clearing the screen, displaying the same cross-section and prompting the user with the message "SELECT POINT FOR ARS CURVE." A second requirement for describing ARS solids is that all the intermediate curves (not first or last curve) be closed curves. This means that the first and last point of a curve have the same position. The user is thus free to select points that describe a curve which satisfy any arbitrary shape requirement. In the case of describing internal air, the curve would be confined to the shell surrounding the internal compartment. Figure 12 shows the example of the internal air boundary curve for the inverted tumbler. Line segments with arrowheads are displayed on the screen to aid the user while the ARS curve is being constructed. The ARS Curve point selection mode terminates automatically when the user closes the curve (i.e., the last point matches the first point). When the user closes the ARS curve, the message "END OF CURVE" is displayed on the screen. Figure 13 illustrates this for the example of the inverted tumbler. The program resumes when the user presses the carriage return (CR), key. Consideration need be directed to two further requirements for describing the ARS solid. Each curve of the ARS solid must have the same number of points. This number (not to exceed 19) is automatically set by the user depending on the number of points needed to define the first closed curve. Therefore, each subsequent curve <u>must</u> have the same number of points as the first curve. Additionally, the consecutive points in adjacent ARS curves should retain a "reasonable" degree of cadence or correspondence. Figure 14 illustrates the display on the screen which aids the user in dealing with the two additional ARS requirements outlined above. This display includes a "star" along with the usual cross section and related prompting messages. The star-like guide is centered at the lateral position of the first degenerate ARS curve which was user defined. Each radial arrow in the star points to the user selected points of the preceding curve of tne ARS.

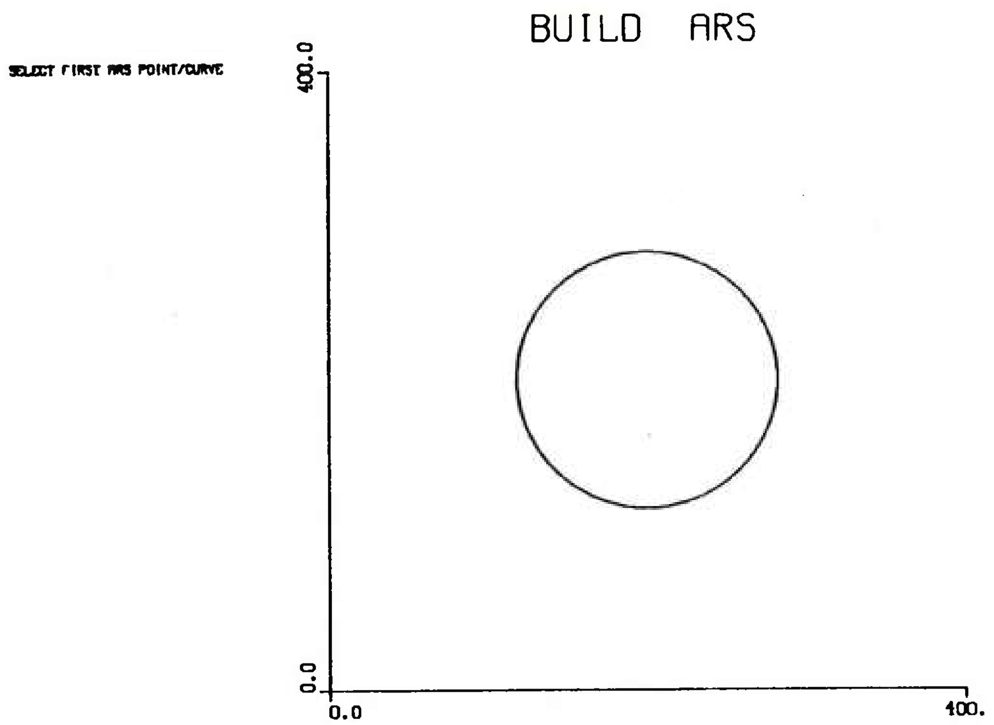


Figure 11. Inverted Tumbler - First Display

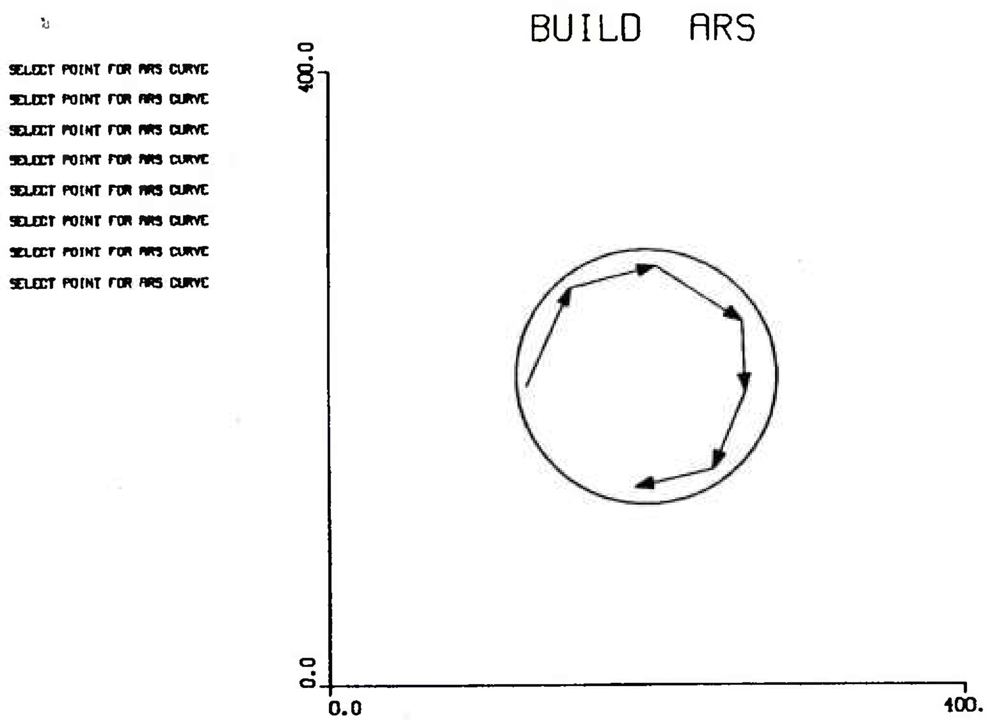


Figure 12. Inverted Tumbler - Second Display

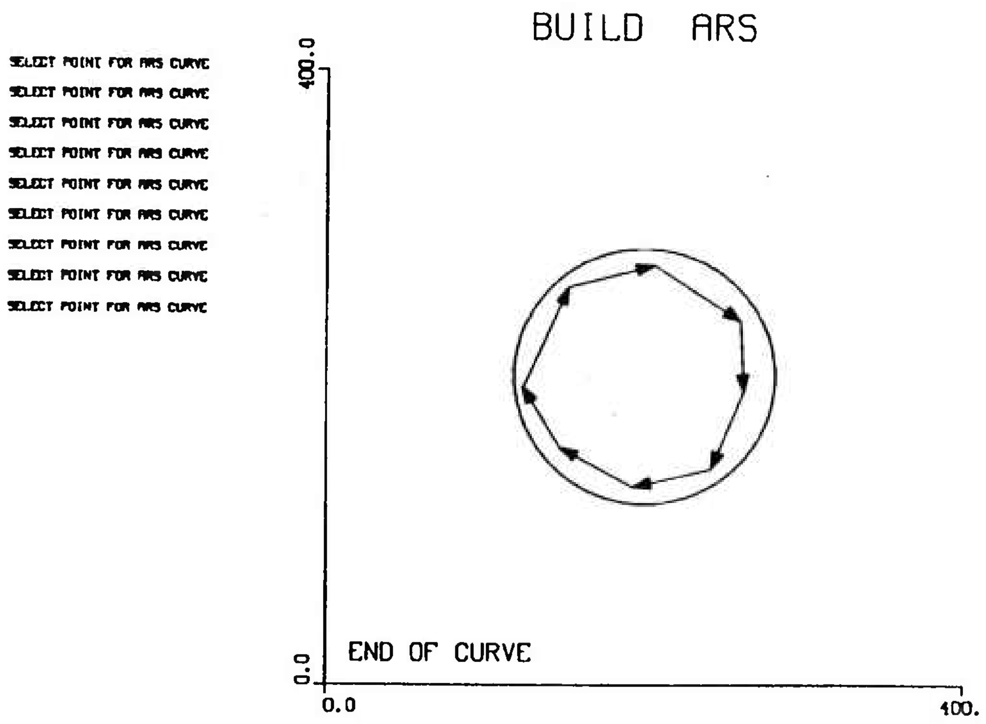


Figure 13. Inverted Tumbler - Second Display - End

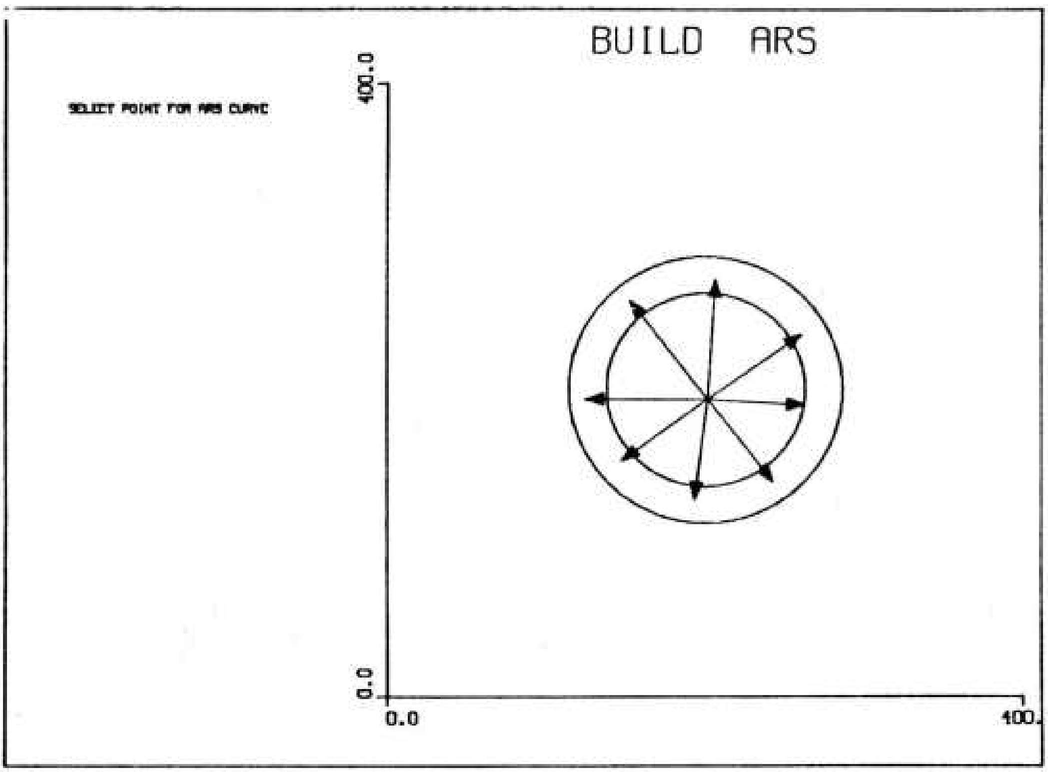


Figure 14. Inverted Tumbler - Third Display - Start

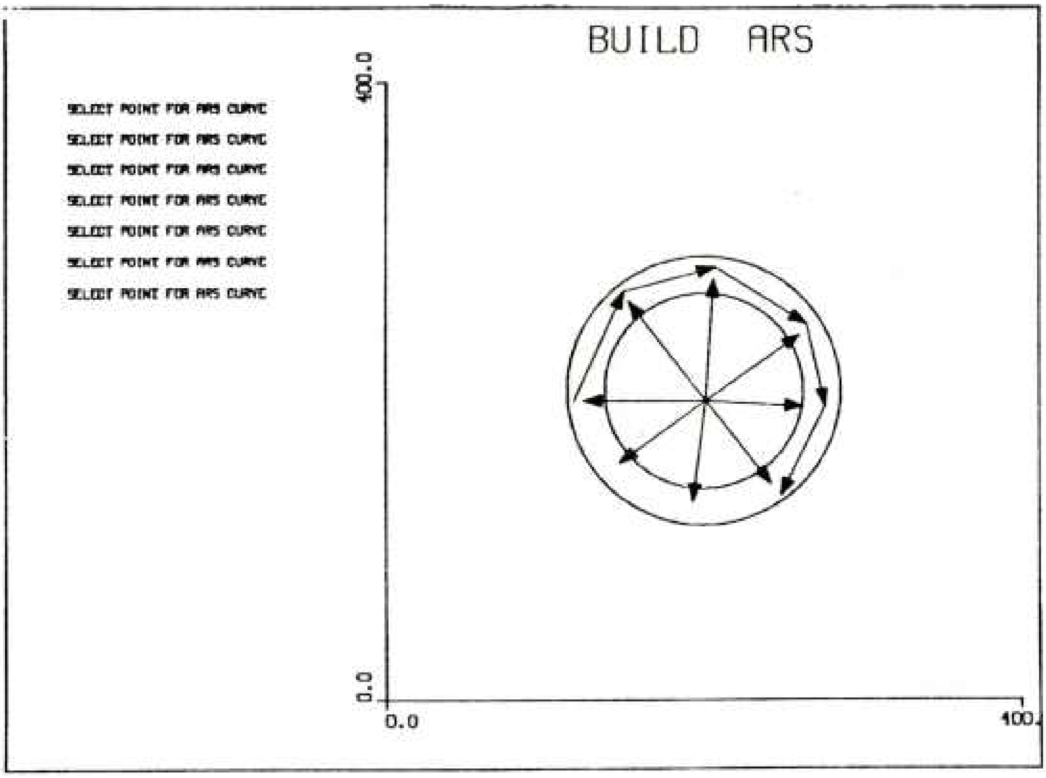


Figure 15. Inverted Tumbler - Third Display - Midway

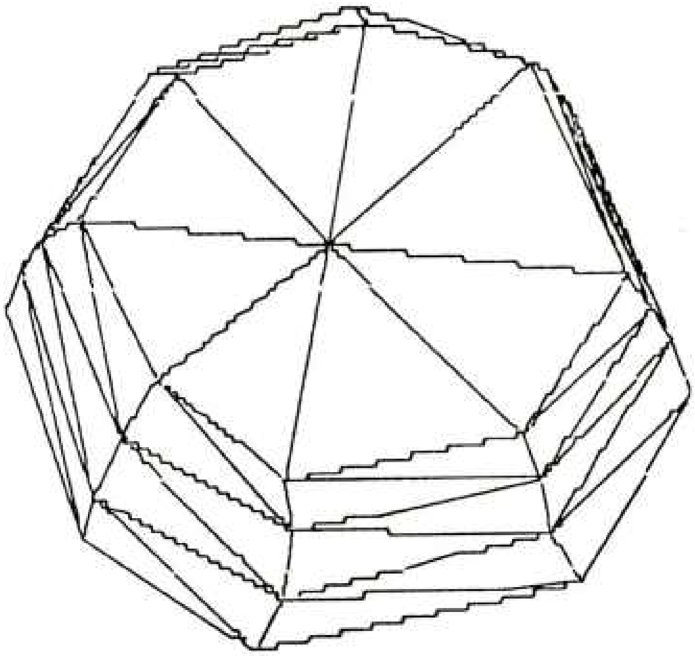


Figure 16. Perspective View of Completed ARS Solid

BUILD ARS (cont.)

The purposes of star guide are twofold: It helps the user to keep track of the number of points that now must be used in defining the curve, and it aids the user in selecting points in the vicinity of the same angular zone to maintain the cadence mentioned above. Figure 15 illustrates this by showing the user defined third ARS curve partially completed. When the curve is completed, the message "END OF CURVE" is displayed. The user presses the carriage return key and the process described above repeats for all of the remaining ARS curves. In order to save this file the user should enter the command SAVE,PUNCH after returning to the operating system. Figure 16 illustrates a perspective view of the ARS solid which was described in this example. To exit prematurely from this procedure, the user need only move the horizontal cross-hair below the plot axis while selecting points. The screen will be cleared and the menu displayed again.

ZOOM

This function, as the name implies, permits the user to optionally expand a small region of the displayed plot for convenient viewing. Initially the current cross-section plot in PLOTFILE is displayed on the graphics screen. Figure 17 illustrates an example with a cross-sectional view of a tank cupola. The user is required to press a punctuation key to continue this procedure. The prompting message "SELECT LOWER LEFT CORNER" instructs the user to define the lower left corner of a "window" which will later be expanded to fill up the whole plot area. The "window" definition operation is performed by the user through the usual use of the cross hairs and punctuation key. The user then responds similarly to the next prompting message "SELECT UPPER RIGHT CORNER." The user defined window area is then magnified and displayed on the graphics screen. Figure 18 illustrates the enlarged view of the window area shown in Figure 17. This procedure will also function on plot files created by PICTUR provided that the title card is modified as discussed for the DISPLAY procedure.

EXIT

This menu entry allows the user to return to the network operating system (NOS) to perform other computer operations possibly unrelated to CADAIR.

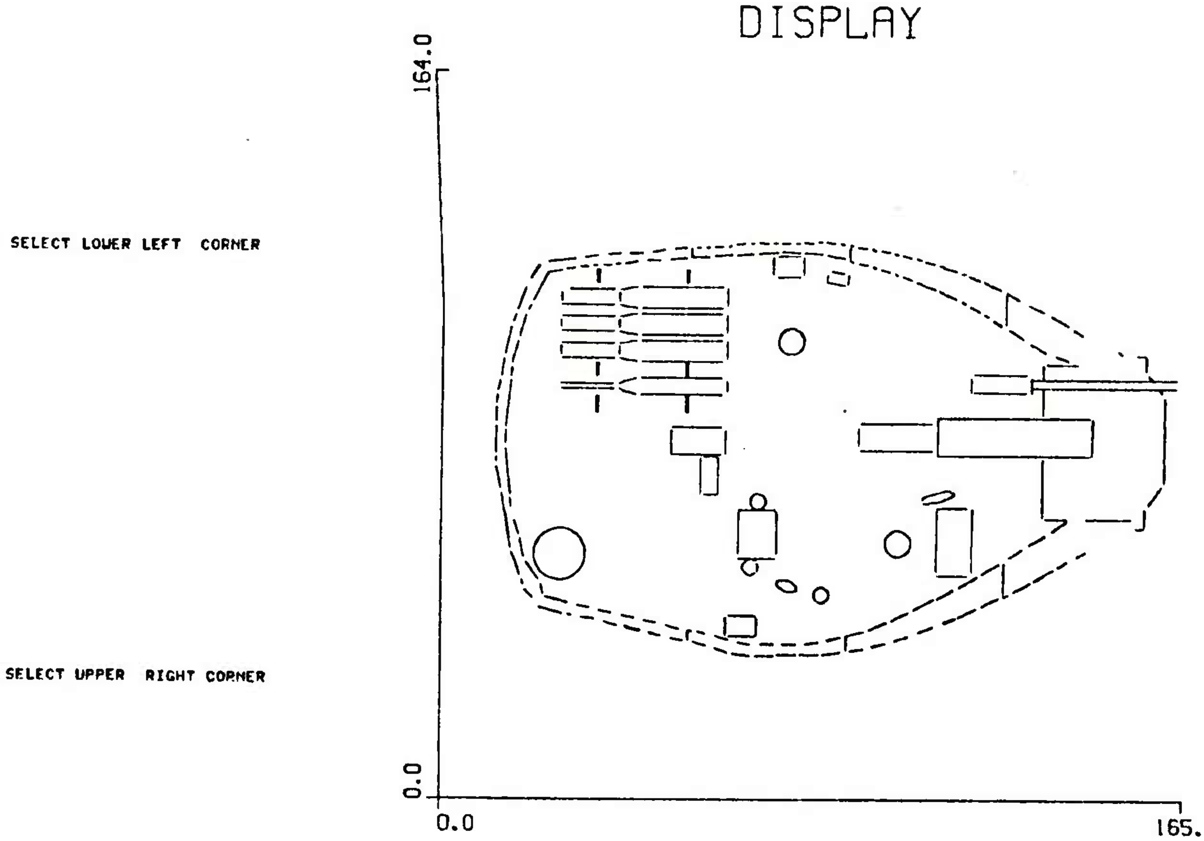


Figure 17. ZOOM Example - Start

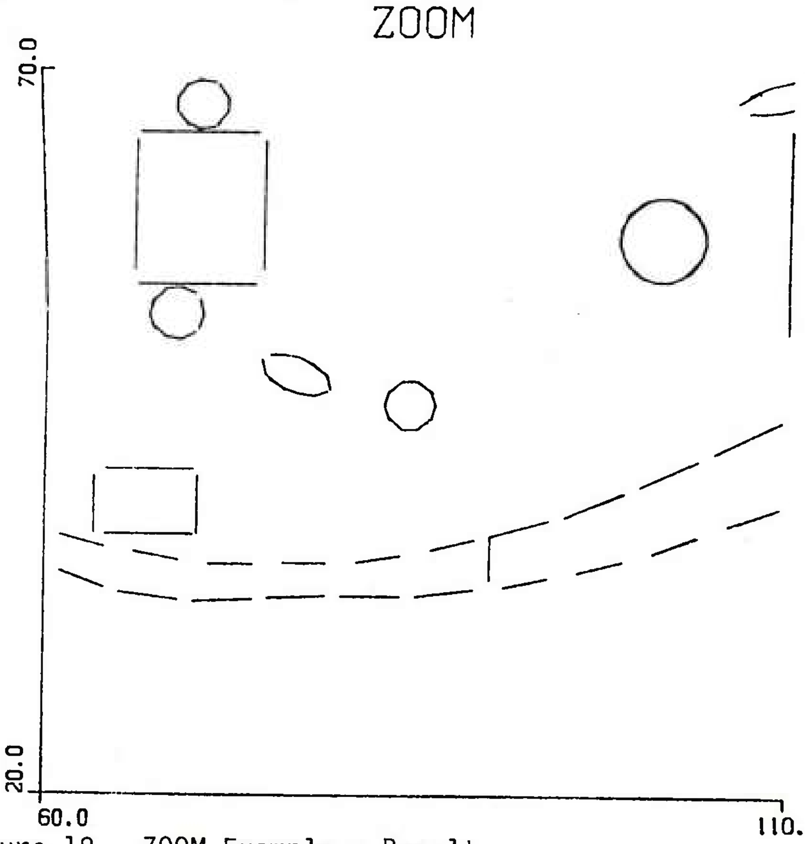


Figure 18. ZOOM Example - Result

VI. ARS COORDINATE TRANSLATION

The ARS solid described by the preceding technique may need to undergo a coordinate translation before it is used in the COM-GEOM description. This is necessary because the XSECT option of the GIFT code changes the coordinate system of the COM-GEOM description as it creates the cross-section plot file. The amount of coordinate change depends on how the XSECT option was set up to run. Figure 19 illustrates the input required by the XSECT option which defines the boundary of the cross-section plot.

1-8	9-16	17-24	25-32	33-40	41-48	49-56	57-64	65-72	73-80
P(1)	P(2)	P(3)	P(4)	P(5)	P(6)	P(7)	P(8)	P(9)	

FORMAT (9F8.0)

P(1-3) - Specify the x, y, and z coordinate of the point in the upper left corner on plotter of cross section.

P(4-6) - Specify the x, y, and z coordinate of the point in the lower left corner on plotter of cross section.

P(7-9) - Specify the x, y, and z coordinate of the point in the lower right corner on plotter of cross section.

Figure 19. Plane Card for XSECT Option

Figure 20 shows a cross-sectional plot of a target with the parameters of Figure 19 indicated on the drawing. The coordinates of the points of the XSECT output file include no negative values. Table I summarizes the required translation of the ARS solid in order that it be compatible with the associated COM-GEOM description. Additionally, in case 2 the Y and Z coordinate values must be exchanged. In case 3 both the X and Z values and then the Y and Z coordinate values need be exchanged, respectively.

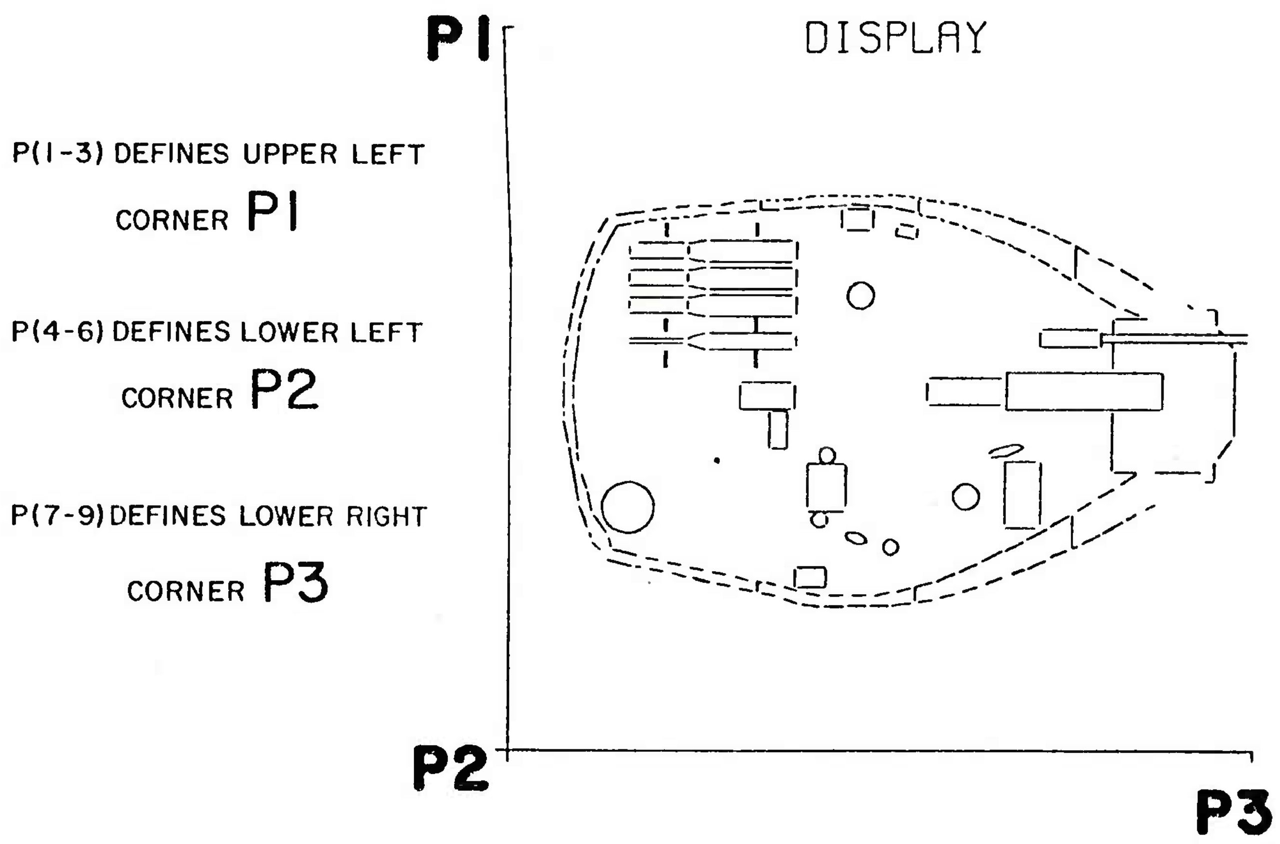


Figure 20. XSECT Plot Defined by COM-GEOM Coordinates

Table 1. Coordinate Transformation Formulae

CASE 1: Z-Plane XSECT Plots ($P_3 = P_6 = P_9$)

Translate ARS solid X values by minimum of P_1, P_4 or P_7.
Translate ARS solid Y values by minimum of P_2, P_5 or P_8.

CASE 2: Y-Plane XSECT Plots ($P_2 = P_5 = P_8$)

Translate ARS solid X values by minimum of P_1, P_4 or P_7.
Translate ARS solid Y values by minimum of P_3, P_6 or P_9.
Exchange the Z and Y values of the ARS solid.

CASE 3: X-Plane XSECT Plots ($P_1 = P_4 = P_7$)

Translate ARS solid Y values by minimum of P_2, P_5 or P_8.
Translate ARS solid Z values by minimum of P_3, P_6 or P_9.
Exchange the X and Z values of the ARS solid; then exchange the Y and Z values of the ARS solid.

VII. DISCUSSION

The preceding description of the CADAIR program was largely concerned with its single utility for describing internal air in COM-GEOM descriptions. There are, however, several other possible uses for the CADAIR program. COM-GEOM descriptions of armored vehicles are often required to include many small "boxes" (i.e., radio, control panels, etc.) that may be attached to the vehicle main armor. In the regular process of modeling these boxes, there often are problems with the boxes overlapping the armor or each other in the COM-GEOM description. The CADAIR program may be used for modeling these small boxes with simple (4 pts/curve) ARS solids. The advantage is clear for the user being able to see where the "boxes" are placed in relation to other target components to avoid overlaps. The problem of "overlaps" in COM-GEOM descriptions has incurred many delays and cost increases for doing target descriptions.

It is occasionally desired to quantitatively determine the protection afforded an armored vehicle through the addition of a ballistic liner. For the case of curved tank turrets, it can prove troublesome to modify COM-GEOM descriptions to include a liner. In these situations, advantage may be realized through the use of the CADAIR program. The XSECT output file may be simulated by other means in order to utilize the CADAIR program to construct original COM-GEOM descriptions. Figure 2 illustrates such an example for the M60A1 turret which was created through use of the CADAIR program. In this case, the tank manufacturer made available a series of drawings which showed "cross-cut" sections of the turret casting. Measurements were taken from these drawings in order to build a plot file (XSECT equivalent output file) suitable as input for the CADAIR program. Figure 21 illustrates a typical ARS curve made during this particular exercise of the CADAIR program. The ARS solids which describe the M60A1 turret exterior surface are shown in Figure 2.

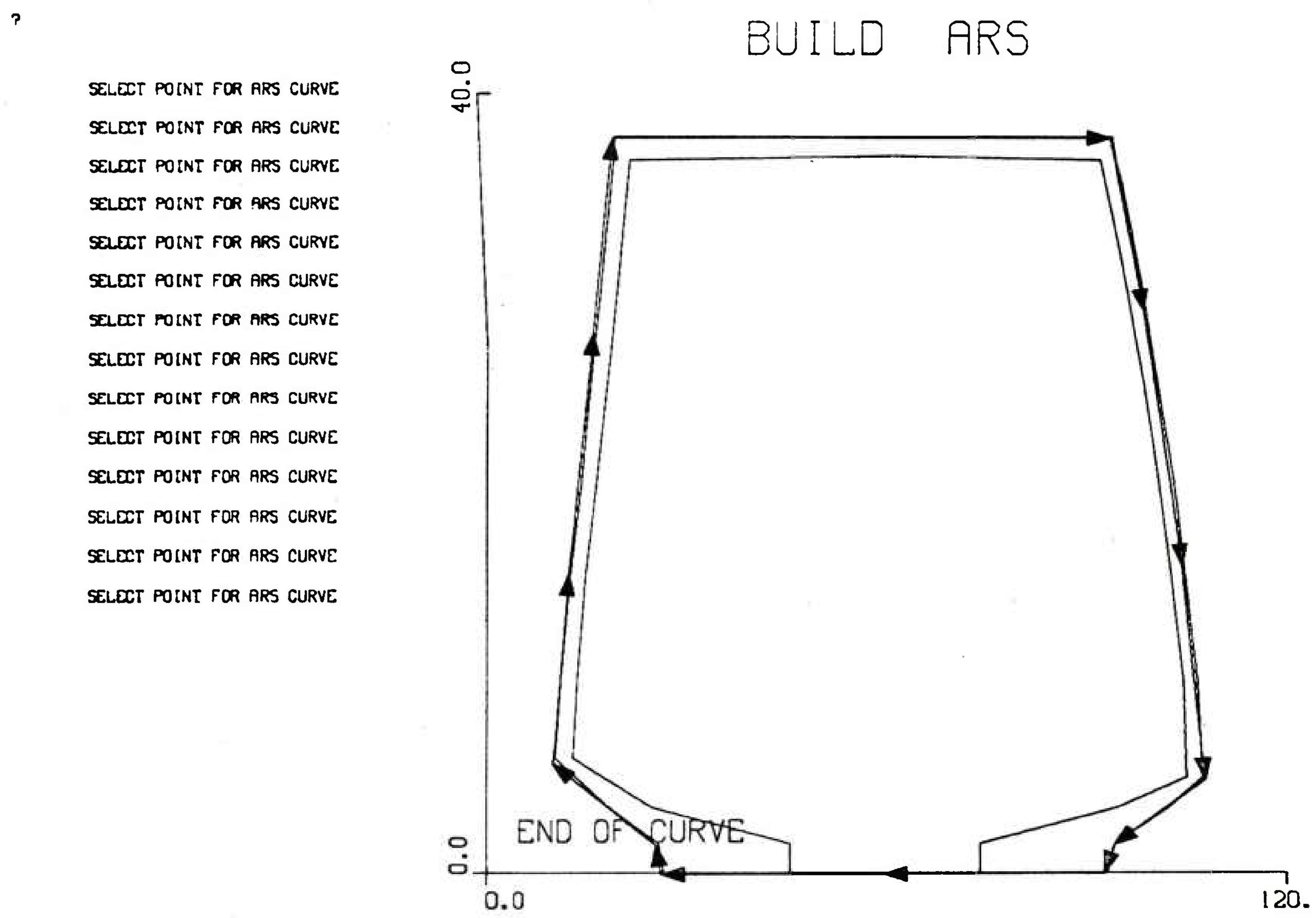


Figure 21. Turret Cross-Cut

APPENDIX A

Combinatorial Geometry Background

Combinatorial Geometry Background

The GIFT computer code requires a combinatorial geometry (COM-GEOM) target description as input data. Familiarization with the COM-GEOM technique and terminology is required to understand the target description. The following is a brief introduction to the COM-GEOM technique of target description. Reference 1 gives a more detailed account of the COM-GEOM method as required for input to the GIFT code.

Engineering drawings, manuals, photographs or other descriptive material are required to produce a COM-GEOM description. The COM-GEOM technique utilizes twelve basic geometric solids (see Table A-1) combined under three set-theory (BOOLEAN) type operations to define the shape and location of each component of a target. A complete COM-GEOM description contains the three distinct parts: a solid table, a region table and a region identification table.

A solid is defined as one of the twelve geometric shapes available for COM-GEOM descriptions. The parameters of a solid give its location, size and orientation within the coordinate system established for the target. Each solid is uniquely numbered and its parameters listed in the solid table.

A region is the space occupied by a single solid or combination of solids. Solids are combined using the three operations: intersection (+), union (OR) and difference (-). The intersection (+) of two solids is defined as the space in common with both solids. The union (OR) of two solids is defined as the space in both of the solids. The difference (-) of two solids is defined as the space in the first solid minus the space of the second solid. Figure A-1 is a graphic illustration of these three operations. Any number of solids from the solid table may be used to define a region. Each region is uniquely numbered and its defined combination of solids is listed in the region table.

In the region identification table, each region is assigned an identification code number. These code numbers either identify each specific region as a component of the target or as an air space. Space not described as a region is assigned the air space code "01" by the GIFT code. It is not necessary to describe the inside air of a target, in which case both inside and outside air will be identified by the 01 space code. However, in many targets, it is important to distinguish between inside and outside air. For these targets, all interior space is described as a region and identified as inside air, leaving the 01 space code for outside air only. The RAYAIR subroutine of the GIFT code allows any region identified with a space code to overlap any region identified with an item code or the same space code. However, regions with different code numbers cannot overlap.

Table A-1. Geometric Solids Used in COM-GEOM Descriptions

SYMBOL	SOLID NAME
RPP	Rectangular Parallelepiped
BOX	Box
RAW	Right Angle Wedge
ARB	Arbitrary Convex Polyhedron
ARS	Triangular Surfaced Polyhedron
ELL	Ellipsoid of Revolution
SPH	Sphere
RCC	Right Circular Cylinder
REC	Right Elliptical Cylinder
TRC	Truncated Right Angle Cone
TEC	Truncated Elliptic Cone
TOR	Torus

The region identification table also allows 40 alphanumeric characteristics of descriptive data per region. The analyst needs to know the type and percentage of material making up each region. The percentage value is used to produce an equivalent line-of-sight thickness of the material type. This information is included in the 40 characters of descriptive data in the region identification table.

The three tables described above constitute a complete COM-GEOM target description as required for input to the GIFT computer code.

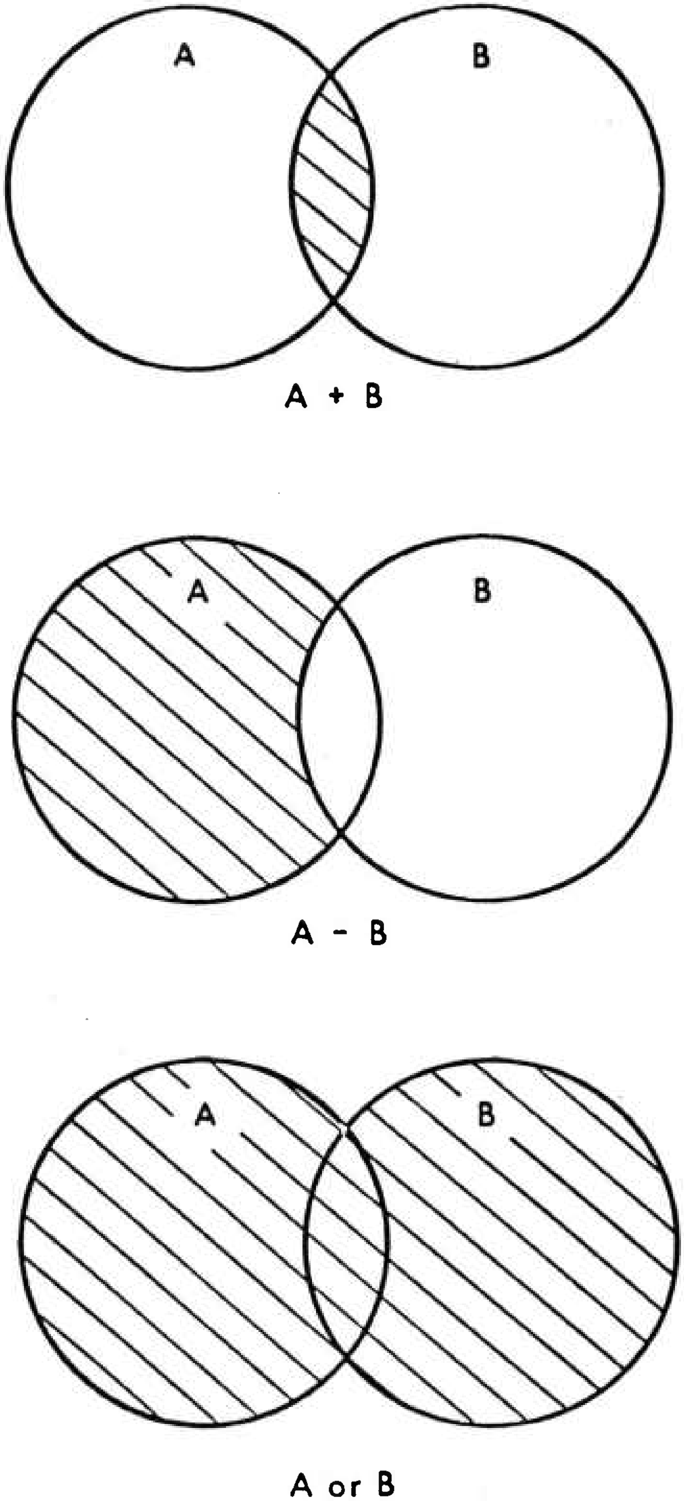


Figure A-1. Intersection (+), Subtraction (-), Union (OR) of Solids

APPENDIX B

CADAIR Program Listing

```
      PROGRAM CADAIR (INPUT,OUTPUT,PUNCH,TAPE5,TAPE6=OUTPUT,TAPE7,TAPE10
     1   ,TAPE8=PUNCH,TAPE12)
C
C
C 'CADAIR' IS AN INTERACTIVE GRAPHICS PROGRAM WHICH AIDS THE USER
C IN CONSTRUCTING 'ARS' SOLIDS FOR COM-GEOM DESCRIPTIONS. THIS
C VERSION OF 'CADAIR' INITIATES COMMUNICATIONS WITH THE TEKTRONICS
C MODEL 4010 GRAPHICS TERMINAL AT 9600 BAUD.  SUBROUTINES IDENTIFIED
C BELOW MAKE EXTENSIVE USE OF THE 'DISSPLA' LIBRARY WHICH IS THE
C PROPRIETARY PRODUCT OF ISSCO,INC.
C
C
C ***        MENU DEFINITIONS        ***
C
C REWIND     - REWIND TAPE12 (PLOTFILE)  TO BEGINNING OF TAPE
C BACKSPACE  - REWIND TAPE12 (PLOTFILE) TO START OF PREVIOUS PLOT
C DISPLAY    - DISPLAY CURRENT PLOT ON GRAPHICS SCREEN
C BUILD ARS  - ASSIST USER IN CONSTRUCTING AN  ARS SOLID
C ZOOM       - 'ZOOM IN' ON DISPLAYED PLOT
C EXIT       -  RETURN  TO OPERATING SYSTEM  (NOS)
C
C
      COMMON /ZAP/ ICONT
      ICONT=0
      CALL TK4010 (9600)
      CALL SETDEV (6,6)
    1 CALL CLEAR
      CALL MENU
      CALL CURSOR (CX,CY)
      CALL ENDGR (0)
      CALL CLEAR
      PRINT *, CX,CY
C
C
      IF (CY.LT.686.0.AND.CY.GT.655.) CALL REDO
      IF (CY.LT.655.0.AND.CY.GT.624.) CALL BACKUP
      IF (CY.LT.624.0.AND.CY.GT.593.) CALL PICT
      IF (CY.LT.593.0.AND.CY.GT.562.) CALL DRAW
      IF (CY.LT.562.0.AND.CY.GT.531.) CALL ZOOM
      IF (CY.LT.531.0.AND.CY.GT.500.) CALL OUT
C
      GO TO 1
      END
      SUBROUTINE CLEAR
C
C SUBROUTINE CLEAR  ERASES THE GRAPHICS SCREEN
C
      IRACE=00074035403340140000B
      CALL CONNEC (10)
      WRITE (10) IRACE
      CALL DISCON (10)
      RETURN
      END
      SUBROUTINE MENU
C
C SUBROUTINE MENU   DISPLAYS THE MENU PROCEDURES ON THE SCREEN
C
      CALL PAGE (8.1315,6.2)
      CALL PHYSOR (0.63,0.59)
      CALL TITLE (' ',1,' ',0,' ',0,2.0,5.2)
      CALL FRAME
      CALL MESSAG ('REWIND',6,0.2,4.75)
      CALL MESSAG ('BACKTRACK',9,0.2,4.5)
```

```
      CALL MESSAG ('OISPLAY',7,0.2,4.25)
      CALL MESSAG ('BUILO ARS',9,0.2,4.0)
      CALL MESSAG ('ZOOM',4,0.2,3.75)
      CALL MESSAG ('EXIT',4,0.2,3.5)
      RETURN
      ENO
      SUBROUTINE CURSOR (CX,CY)
C
C SUBROUTINE CURSOR TURNS ON THE TERMINAL CROSS-HAIRS AND FACILATES
C ( USER SELECTED ) SCREEN COORDINATE OATA TRANSFER TO THE HOST
C COMPUTER
C
      OIMENSION IHY(2)
      ITRAN=00060012001500000000B
      ITURN=00074035403340320000B
      MHX=00000000037000000000B
      MLX=00000000000000370000B
      MHY=00000000000000000037B
      MLY=00370000000000000000B
      CALL TSENO
      CALL CONNEC (10)
      WRITE (10) ITRAN,ITURN
      BUFFER IN( 10,1)(IHY(1),IHY(2))
      CALL DISCON (10)
      JHX=ANO(IHY(1),MHX)
      JLX=AND(IHY(1),MLX)
      JHY=ANO(IHY(1),MHY)
      JLY=ANO(IHY(2),MLY)
      KHX=SHIFT(JHX,-19)
      KLX=SHIFT(JLX,-12)
      KHY=SHIFT(JHY,5)
      KLY=SHIFT(JLY,-48)
      LX=OR(KHX,KLX)
      LY=OR(KHY,KLY)
      CX=FLOAT(LX)
      CY=FLOAT(LY)
      RETURN
      END
      SUBROUTINE REOO
C
C SUBROUTINE REOO  INITIATES THE PROCEOURE FOR THE MENU ENTRY
C 'REWINO'
C
      COMMON /ZAP/ ICONT
C REWINO GRAPHICS FILE  ATTACHEO TO TAPE12
      REWINO 12
      ICONT=0
      RETURN
      ENO
      SUBROUTINE BACKUP
C
C SUBROUTINE BACKUP INITIATES THE PROCEDURE FOR THE MENU ENTRY
C 'BACKSPACE'
C
      COMMON /ZAP/ ICONT
C BACKUP THE GRAPHICS FILE TO BEGINNING OF PREVIOUS PLOT
      IF (ICONT.EQ.0) RETURN
      REWINO 12
      ICONT=ICONT-1
      CALL SKIPFE (12,ICONT,0)
      RETURN
      ENO
      SUBROUTINE PICT
C
C SUBROUTINE PICT  INITIATES THE PROCEOURE FOR THE MENU ENTRY
C 'DISPLAY'
```

```
C
      DIMENSION X(300), Y(300), FIL(999)
      COMMON /ZAP/ ICONT
      COMMON /ZIP/ ZZ(30), HOR, VET, NC
      COMMON /ZOP/ HAR, VAT
      IF (ICONT.EQ.0) IEND=100
      IF (ICONT.GE.IEND) REWIND 12
      IF (ICONT.GE.IEND) RETURN
    1 READ (12,7) NC,(ZZ(I),I=1,NC)
      IF (EOF(I2)) 1,2
    2 IF (NC.EQ.I) READ (12,8) A,B,HOR,VET
      IF (NC.NE.I) READ (12,8) A,B,C,HOR,VET
      CALL PHYSOR (3.0,0.59)
      CALL TITLE ('  DISPLAY ',10,' ',1,' ',1,5.0,5.0)
      CALL GRAF (0.0,HOR,HOR,0.0,VET,VET)
    3 READ (12,9) N
      IF (N.EQ.I) READ (I2,5) HO,VE
      IF (N.EQ.1) GO TO 3
      IF (N.EQ.-2) READ (12,6) NF
      IF (N.EQ.-2) READ (12,5) (FIL(IJ),IJ=1,NF)
      IF (N.EQ.-2) GO TO 3
      IF (N.EQ.0) GO TO 4
      READ (12,I0) (X(I),Y(I),I=1,N)
      CALL CURVE (X,Y,N,0)
      GO TO 3
    4 CONTINUE
      CALL CURSOR (CX,CY)
      CALL ENDGR (0)
      CALL RESET ('PHYSOR')
      ICONT=ICONT+1
      HAR=HOR
      VAT=VET
      IEND=NC
      RETURN
C
    5 FORMAT (2F12.4)
    6 FORMAT (1I10)
    7 FORMAT (I5,20F5.I)
    8 FORMAT (6F12.4)
    9 FORMAT (1I10)
   10 FORMAT (6F12.4)
      ENO
      SUBROUTINE DRAW                                                     * 171*
C
C SUBROUTINE DRAW  INITIATES THE PROCEDURE FOR THE ENTRY
C 'BUILD ARS'
C
      DIMENSION X(30,30), Y(30,30), Z(30,30), XC(2), YC(2)
      COMMON /ZAP/ ICONT
      COMMON /ZIP/ ZZ(30), HOR, VET, NC
      CALL REOO
      AXS=365.0$AYS=63.0
      CALL CLEAR
      CALL PACT
      IF (NC.EQ.1) CALL ENDPL (0)
      IF (NC.EQ.1) RETURN
      CALL HEIGHT (.07)
      CALL MESSAG ('SELECT FIRST ARS POINT/CURVE$',100,-2.5,5.0)
      CALL RESET ('HEIGHT')
      CALL CURSOR (CX,CY)
      IF (CX.LT.AXS.OR.CY.LT.AYS) CALL ENDPL (0)
      IF (CX.LT.AXS.OR.CY.LT.AYS) RETURN
      CX=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
      CY=(CY-(780.0*0.59/6.2))*VET/(780.0*5.0/6.2)
      CALL ENOGR (0)
      DO 1 I=1,30
```

```
      X(I,1)=CX$Y(I,1)=CY$Z(I,1)=ZZ(1)
    1 CONTINUE
      CALL REDO
      CALL CLEAR
      CALL PACT
      I=0$FLG=0.0$XC(1)=0.0
    2 CALL HEIGHT (.07)
      YPOS=5.0-.25*FLOAT(I)
      CALL MESSAG ('SELECT POINT FOR ARS CURVES',100,-2.5,YPOS)
      CALL RESET ('HEIGHT')
      I=I+1
      CALL CURSOR (CX,CY)
      IF (I.EQ.1) BX=CX
      IF (I.EQ.1) BY=CY
      DEL=SQRT((BX-CX)**2)+ABS((BY-CY)**2)
      IF (I.EQ.1) DEL=10.0
      IF (DEL.LT.9.0) FLG=1.0
      X(I,2)=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
      Y(I,2)=(CY-(780.0*0.59/6.2))*VET/(780.*5.0/6.2)
      IF (CX.LT.AXS.OR.CY.LT.AYS) CALL ENDPL (0)
      IF (CX.LT.AXS.OR.CY.LT.AYS) RETURN
      Z(I,2)=ZZ(1)
      A=XC(1)
      IF (A.EQ.0.0) XC(1)=X(I,2)
      IF (A.EQ.0.0) YC(1)=Y(I,2)
      IF (A.EQ.0.0) GO TO 2
      XC(2)=X(I,2)
      YC(2)=Y(I,2)
      CALL RLVEC (XC(1),YC(1),XC(2),YC(2),1201)
      XC(1)=XC(2)
      YC(1)=YC(2)
      IF (I.GT.19) CALL MESSAG (16HTOO MANY POINTS$,100,.2,.2)
      IF (I.GT.19) CALL ENDGR (0)
      IF (I.GT.19) CALL CURSOR (CX,CY)
      IF (I.GT.19) RETURN
      IF (FLG.EQ.0.0) GO TO 2
      CALL MESSAG ('END OF CURVES',100,.2,.2)
      CALL ENDPL (0)
      NP=I
      N=2
      X(NP,2)=X(1,2)$Y(NP,2)=Y(1,2)
      LIM=NC+1
    3 CONTINUE
      N=N+1
      CALL CLEAR
      CALL PACT
      XC(1)=0.0
      NZ=NP-1
      L=N-1
      DO 4 K=1,NZ
      CALL RLVEC (X(1,1),Y(1,1),X(K,L),Y(K,L),1201)
    4 CONTINUE
      NPP=NP-1
      DO 5 J=1,NPP
      CALL HEIGHT (.07)
      YPOS=5.0-.25*FLOAT(J)
      CALL MESSAG ('SELECT POINT FOR ARS CURVES',100,-2.5,YPOS)
      CALL RESET ('HEIGHT')
      CALL CURSOR (CX,CY)
      X(J,N)=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
      Y(J,N)=(CY-(780.0*0.59/6.2))*VET/(780.0*5.0/6.2)
      IF (CX.LT.AXS.OR.CY.LT.AYS) CALL ENDPL (0)
      IF (CX.LT.AXS.OR.CY.LT.AYS) RETURN
      NNN=N-1
      Z(J,N)=ZZ(NNN)
      A=XC(1)
```

```
      IF (A.EQ.0.0) XC(1)=X(J,N)
      IF (A.EQ.0.0) YC(1)=Y(J,N)
      IF (A.EQ.0.0) GO TO 5
      XC(2)=X(J,N)
      YC(2)=Y(J,N)
      CALL RLVEC (XC(1),YC(1),XC(2),YC(2),1201)
      XC(1)=XC(2)
      YC(1)=YC(2)
    5 CONTINUE
      X(NP,N)=X(1,N)
      Y(NP,N)=Y(1,N)
      Z(NP,N)=Z(1,N)
      IF (N.LT.LIM) CALL MESSAG (13HEND OF CURVES,100,.2,.2)
      IF (N.LT.LIM) CALL ENDPL (0)
      IF (N.LT.LIM) GO TO 3
      CALL MESSAG ('END OF CURVES',100,.2,.2)
      CALL ENDPL (0)
      NT=NC+2
      DO 6 I=1,NP
      X(I,NT)=X(I,1)
      Y(I,NT)=Y(I,1)
      Z(I,NT)=ZZ(NC)
    6 CONTINUE
      PUNCH (8,8) NT,NP
      DO 7 N=1,NT
      PUNCH (8,9) (X(I,N),Y(I,N),Z(I,N),X(I+1,N),Y(I+1,N),Z(I+1,N),I=1,
     1  NP,2)
    7 CONTINUE
      RETURN
C
    8 FORMAT (3X,3HARS,4X,2I10)
    9 FORMAT (10X,6F10.4)
      END
      SUBROUTINE ZOOM
C
C SUBROUTINE  ZOOM  ENLARGES A USER SELECTED AREA OF THE DIS-
C PLAYED PLOT
C
      DIMENSION X(300), Y(300), FIL(999), ID1(3), ID2(3)
      COMMON /ZAP/ ICONT
      COMMON /ZOP/ HAR, VAT
      DATA ID1 /10HSELECT LOW, 10HER LEFT  C, 10HORNER     /
      DATA ID2 /10HSELECT UPP, 10HER  RIGHT , 10HCORNER    /
      CALL BACKUP
      CALL PICT
C
      HOR=HAR
      VET=VAT
      CALL BACKUP
      PRINT *, ID1
      PRINT *, ID1
      CALL CURSOR (CX,CY)
      CX=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
      CY=(CY-(780.0*.59/6.2))*VET/(780.0*5.0/6.2)
      XLL=CX$YLL=CY
      PRINT *, ID2
      PRINT *, ID2
      CALL CURSOR (CX,CY)
      CX=(CX-(1024.0*3.0/8.1315))*HOR/(1024.0*5.0/8.1315)
      CY=(CY-(780.0*.59/6.2))*VET/(780.0*5.0/6.2)
      XUR=CX$YUR=CY
      IF (XLL.GT.CX) XUR=XLL
      IF (XLL.GT.CX) XLL=CX
      IF (YLL.GT.CY) YUR=YLL
      IF (YLL.GT.CY) YLL=CY
      XOR=XLL$YOR=YLL
```

```
      HOR=XUR-XLL$VET=YUR-YLL
      CALL CLEAR
      CALL PHYSOR (3.0,0.59)
      CALL TITLE ('    ZOOM    ',10,' ',1,' ',1,5.0,5.0)
      XNEW=AMAX1(HOR,VET)
      XNEW=10.0*FLOAT(IFIX(XNEW/10.0)+1)
      HOR=XNEW
      VET=XNEW
      XOR=10.0*FLOAT(IFIX(XOR/10.0))
      YOR=10.0*FLOAT(IFIX(YOR/10.0))
      XUR=XOR+HOR
      YUR=YOR+VET
      CALL GRAF (XOR,HOR,XUR,YOR,VET,YUR)
    1 READ (12,7) IOENT
      IF (EOF(12)) 1,2
    2 READ (12,8) A,B,C,HOR,VET
    3 READ (12,9) N
      IF (N.EQ.1) REAO (12,6) HO,VE
      IF (N.EQ.1) GO TO 3
      IF (N.EQ.-2) REAO (12,9) NF
      IF (N.EQ.-2) READ (12,6) (FIL(IJ),IJ=1,NF)
      IF (N.EQ.-2) GO TO 3
      IF (N.EQ.0) GO TO 5
      REAO (12,10) (X(I),Y(I),I=1,N)
      IND=1
      OO 4 I=1,N
      IF (X(I).LT.XOR.OR.X(I).GT.XUR) GO TO 4
      IF (Y(I).LT.YOR.OR.Y(I).GT.YUR) GO TO 4
      X(IND)=X(I)$Y(IND)=Y(I)
      IND=INO+1
    4 CONTINUE
      N=IND-1
      IF (N.LT.2) GO TO 3
      CALL CURVE (X,Y,N,0)
      GO TO 3
    5 CONTINUE
      CALL CURSOR (CX,CY)
      CALL ENOGR (0)
      CALL RESET ('PHYSOR')
      ICONT=ICONT+1
      RETURN
C
C
    6 FORMAT (2F12.4)
    7 FORMAT (8A10)
    8 FORMAT (6F12.4)
    9 FORMAT (1I10)
   10 FORMAT (6F12.4)
      END
      SUBROUTINE OUT
C RETURN TO CYBER OPERATING SYSTEM
      CALL CLEAR
      STOP
      ENO
      SUBROUTINE PACT
      OIMENSION X(300), Y(300), FIL(999)
      COMMON /ZAP/ ICONT
      COMMON /ZIP/ ZZ(30), HOR, VET, NC
    1 READ (12,5) NC,(ZZ(I),I=1,NC)
      IF (EOF(12)) 1,2
    2 READ (12,6) A,B,C,HOR,VET
      CALL PHYSOR (3.0,0.59)
      CALL TITLE ('BUILD  ARS',10,' ',1,' ',1,5.0,5.0)
      CALL GRAF (0.0,HOR,HOR,0.0,VET,VET)
    3 REAO (12,7) N
      IF (N.EQ.0) GO TO 4
```

```
      READ (12,8) (X(I),Y(I),I=1,N)
      CALL CURVE (X,Y,N,0)
      GO TO 3
    4 CONTINUE
      ICONT=ICONT+1
      RETURN
C
    5 FORMAT (I5,15F5.1)
    6 FORMAT (6F12.4)
    7 FORMAT (1I10)
    8 FORMAT (6F12.4)
      END
16.07.37.UCLP, FATM1402C,       0.586KLNS.
```

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